Chapter I

Technologies for Arming the Air Force of the 21st Century

1.0 Introduction

New World Vistas is a study about the Air Force. It is about technology. It is about ideas. Most of all it is about the defense of the United States. The Secretary of the Air Force, Dr. Sheila E. Widnall, and the Chief of Staff, General Ronald R. Fogleman, directed the Air Force Scientific Advisory Board to identify those technologies that will guarantee the air and space superiority of the United States in the 21st century.[1] We have taken the charge as an obligation to find and to create new ideas. We believe those ideas will make the Air Force of the future effective, affordable, and capable in seamless joint and multinational operations in which it achieves its purpose "to fight and to win the Nation's wars."[2]

New World Vistas is documented in detail in over 2000 pages of monographs collected in 15 volumes. The study participants are listed, and abstracts of their work are contained in Appendix B. There are many good ideas and careful descriptions of them in the 15 volumes. In addition, there is a Classified Volume[3] and a volume of important ancillary information obtained during the conduct of the study. And finally, this Summary Volume distills the major ideas from the monographs and integrates them into concepts that will produce a discontinuous or quantum enhancement of the effectiveness of the Air Force. We attempt in this volume to provide compelling reasons for pursuing these ideas, and we establish a path that stretches from today into the future. The definition of the path includes suggestions for significant incorporation of commercial technologies and practices into Air Force operations, and it includes suggestions for both change and reinforcement of the ways that the Air Force pursues science and technology goals. Our suggestions are based on the principles embodied in the concept of Global Reach-Global Power, which directs the Air Force to be capable of projecting power and influence worldwide.

We understand the uncertainties that accompany any attempt to predict the future. We may generate ideas that will be notable as humorous objects for future generations rather than notable as accurate visions of the future. We can only base our suggestions on our experience and on our estimates of the needs of the future. Most predictions become increasingly inaccurate with time after a decade or so has passed. Experience has shown, however, that carefully considered predictions are useful in defining new areas of endeavor that lead to new discoveries even if the discoveries are not those predicted. Thus, armed with caveats, confidence, and, perhaps, a small amount of vision we plunge into the task of defining technologies that will arm the Air Force of the 21st century.

We assert that the emphasis of Air Force technology must change. The Cold War presented a single adversary who had well known tactics, systems, and capabilities. Cold War military technology responded to the threat by developing weapon systems designed to respond to particular scenarios. In the process of development, we produced generic capabilities, but they mainly derived from the process of responding to the Soviet threat. System cost was always an important parameter, but it was never the predominant consideration.

---

1. Memorandum to Dr. McCall from General Fogleman, CSAF and Dr. Widnall, SecAF - Appendix A.
2. General Ronald R. Fogleman, Address to Air Force 2025, Maxwell AFB, AL, 6 September 1995.
3. Classified Volume - on file in SAB office

Now, however, no well defined enemy exists. There are scenarios that suffice for some planning purposes, but they are of questionable reality. Rather than responding to a few particular scenarios, military technology now must respond to diverse situations. Cost has become a major factor in the development of all systems. We must also recognize that commercial technologies, which are developing at a rapid pace, have significant military applications. The Air Force must take advantage of new commercial technologies and must counter their use in adversary systems. It is essential that future systems be based on capabilities and cost, perhaps on an equal footing, rather than on solutions to specific problems.

There are two subjects about which the report is silent. The first is National Missile Defense. We do not believe the topic to be unimportant, and it will be apparent that several of the technologies we discuss are applicable. We found, however, that National Missile Defense is embroiled in politics too complex to permit detailed concept definitions to be of use at present. The second subject omitted is Nuclear Weapon Technology. That subject, too, is important, but nuclear weapon technologies are developed outside the Air Force, and the nuclear forces are, at present, prohibited from pursuing new ideas of design or delivery. We do, however, address problems associated with defense against weapons of mass destruction.

Chapter II will address the capabilities which are enabled by the new technologies. We will emphasize the interaction of technologies and capabilities, and we will show how new information sciences connect and enhance capabilities. Next, we will delineate the technologies. A striking feature of the list of technologies is that it is short. From a short list of new technologies and their supporting technologies the Air Force will derive amazingly superior capabilities. Chapter III will suggest what the Air Force should do, what they should stop doing, how to pay for it and how to make it happen. Chapter IV will conclude with organizational considerations and recommendations.

2.0 Fundamental Considerations

We have attempted to define capabilities and technologies that transcend particular missions and apply to all scenarios. We have not divided our recommendations into neat, well-defined categories. We tried, but we found that the power of the technologies and concepts that we recommend is that each cuts across several fundamental capabilities. The Attack Panel Volume presents a detailed method for inverting the matrix and discussing capabilities in terms of tasks to be performed.[4] We believe that the applications will be readily apparent when explained in detail. For example, knowledge and control of information is necessary for all missions, whether in peace or war, logistics or combat. All missions depend on communications and reconnaissance and, therefore, increasingly on space assets. As space assets become increasingly important, space control becomes a necessary part of all missions. Throughout the Force, the necessity of accurate, absolute positioning and timing is apparent. The most efficient way to supply this service is through space assets such as an enhanced, countermeasure-immune Global Positioning System (GPS). A technological thread which runs through many future applications is materials development. Strong, lightweight materials and structures will enable many capabilities in space, aircraft, and weapons.[5]

---

4. Attack Volume
5. Materials Volume

We know that reduced cycle time is a true force multiplier. It is characteristic of reduced cycle time that all components of the Force must operate at a higher tempo. If an airlifter is late with supplies, an attack mission will be delayed, and the choreography of an entire operation can be disrupted. The sensor systems that enable precision delivery of munitions can also be used in aircraft self protection. Technologies and functions will influence all capabilities. The Force will become so tightly integrated in function, and will be so tightly coupled to allies and the other services that boundaries between capabilities will become blurred if they exist at all.

For the purposes of *New World Vistas*, we have assumed that:

- The Air Force will have to fight at large distances from the United States. Some operations may be staged directly from the Continental United States (CONUS). Operations may persist for weeks or months, and they must be executed day and night in all weather.
- The site of the next conflict is unknown. The Air Force must be prepared to fight or to conduct mobility or special operations anywhere in the world on short notice.
- Weapons must be highly accurate, must minimize collateral damage, must minimize delivery and acquisition costs, and must enhance, and be enhanced by, aircraft capabilities.
- Platforms that deliver weapons must be lethal and survivable. They must establish air superiority in areas that are heavily populated with surface to air missiles (SAM’s), and they must carry the attack to all enemy targets, fixed and mobile.
- Adversaries may be organized national forces or terrorist groups.
- Targets may be fixed or mobile and may be well concealed. Target classes will span the range from personnel to armored vehicles and protected command centers and information systems. Operational geography will range from classical battlefields to cities and jungles.
- Adversary capabilities will steadily improve and will be difficult to anticipate. For example, the Air Force must be prepared to defend against improved SAM’s, low observable aircraft, cruise missiles, directed energy weapons, and information attack.
- The Air Force must detect and destroy chemical, biological, and nuclear weapons and their production facilities.
- There will be peacetime missions in areas of local conflict. Aircraft must be protected against SAM’s and ground fire by means other than offensive attack.
- Increasing the pace of operations increases the effectiveness of all operations.
- Cost will be equal in importance to capability.
- The number of people in the Air Force will decrease. Individual performance must be optimized.

2.1 Increased Tempo

All missions establish a cycle of knowing, planning, acting, and assessing. The cycle repeats, and if we are to minimize losses and maximize effect the cycle must repeat as rapidly as possible.

Increased tempo of operations makes the Force appear larger.[6] If an attacker can strike an enemy twice in the time necessary for the defender to respond once, the attacking force appears to the defender to be twice as large as it actually is. Given fixed funding to improve capability, though, one can ask whether it is more effective to spend the allocation on improving the performance of existing weapons or to spend it on increasing delivery, or sortie rate. Improvements in performance are produced by improved accuracy of weapons, for example. The two categories are not completely independent, of course. An accuracy improvement in weapons can reduce the number of sorties required per target. Thus, more targets can be struck in a given time, and the force appears to be larger. A simple mathematical theory to analyze the situation described was devised by F. W. Lanchester,[7] a British aeronautical scientist, in 1907. Although modern warfare is more complex than envisioned by Lanchester, his theory has survived remarkably well, and we use it here to motivate the reader to accept our concentration on increasing

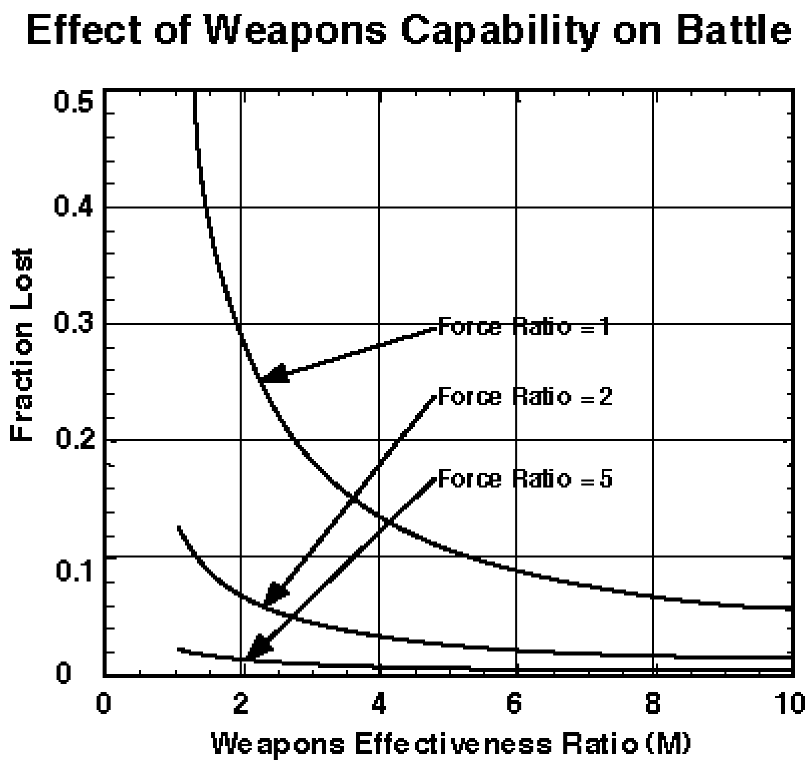


Figure I-1(a)

6. Attack Volume
7. James R. Newman, *The World of Mathematics* , Simon and Schuster, New York, 1956, vol. 4, pp 2136-2157

the tempo of operations. We refer the reader to the reference for a complete description of the Lanchester theory, but we display the results of the theory in figures I-1(a) and I-1(b). Figure I-1(a) shows the fraction of an attacking force lost as a function of weapon effectiveness, M. One can think of effectiveness as accuracy, for example, figure I-1(b) shows the fraction of an attacking force lost as a function of the ratio of the size of the forces. For the purposes of this discussion it will suffice to observe that increasing the force size reduces losses faster than does increasing weapon effectiveness. Because of budget limitations, it is unlikely that we can justify large increases in numbers of aircraft, weapons, or people. Therefore, we will concentrate on technologies which increase the apparent force size through increased tempo of operations.

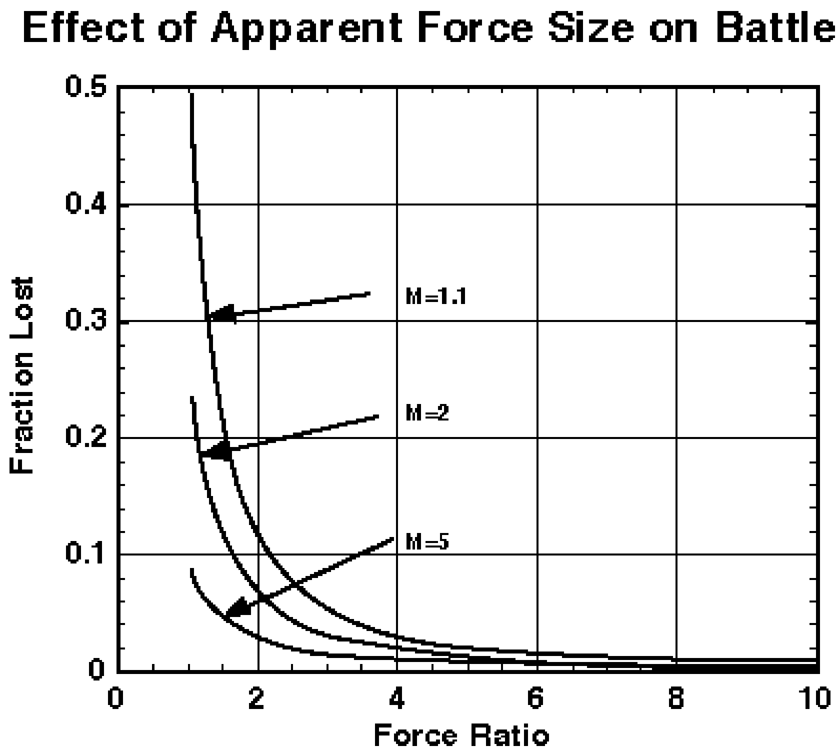


Figure I-1(b)

It is certain that most of the weapon systems that will exist in a decade exist now. The F-22 will be the only new aircraft available in a decade. An aircraft based on the Joint Advanced Strike Technologies (JAST) may appear a decade after that to replace the F-16. By the time that the F-22 and JAST appear, new technologies will be available to enhance their performance, but both aircraft are being designed using extant technologies. Thus, in addition to long range projections, we propose technologies and concepts to enhance the current force during the next ten years. These ideas will also lead to better capabilities for the F-22 and JAST. The technologies that will enhance the early 21st century Force are related to improved weapons, improved communications, and improved generation and exploitation of information. Improvement in the reliability of components such as avionics will be necessary to reduce logistics costs and to maintain extended high tempo operations.

The aircraft now planned for the 21st century, such as the F-22, are superior to existing aircraft in the United States and abroad. They will not, however, produce a discontinuous change[8] in the nature of aerospace warfare. Discontinuous change can occur in several ways. It usually occurs as a result of the introduction of new weapons that rapidly transcend the capabilities of older weapons. Firearms were a discontinuous change over weapons propelled by humans. The machine gun and the tank made the horse obsolete. The airplane destroyed the idea that distance provides protection. To a lesser extent new delivery systems or new tactics can produce a discontinuous change in warfare. The precision guided munition and the stealth aircraft are examples of delivery systems. For certain targets, the precision guided munition increased the destructive power of munitions by as much as a factor of 1000, and the stealthy aircraft reduced the effective range of surface-to-air missiles by a substantial amount. The introduction of naval tactics by Rodney at the Battle of Saints in 1780 and the introduction of the concept we now call reduced cycle time by Nelson at the Battle of Trafalgar in 1805 are examples of the force of a new philosophy of warfare.

3.0 The Future Force

What then are the discontinuous changes of the future, and how are they enabled by technology? Both concepts and technologies are described in detail in subsequent volumes. In this volume we delineate the major features. We will set the stage for the discussions that follow by describing the Air Force that will be built from the concepts and technologies proposed.

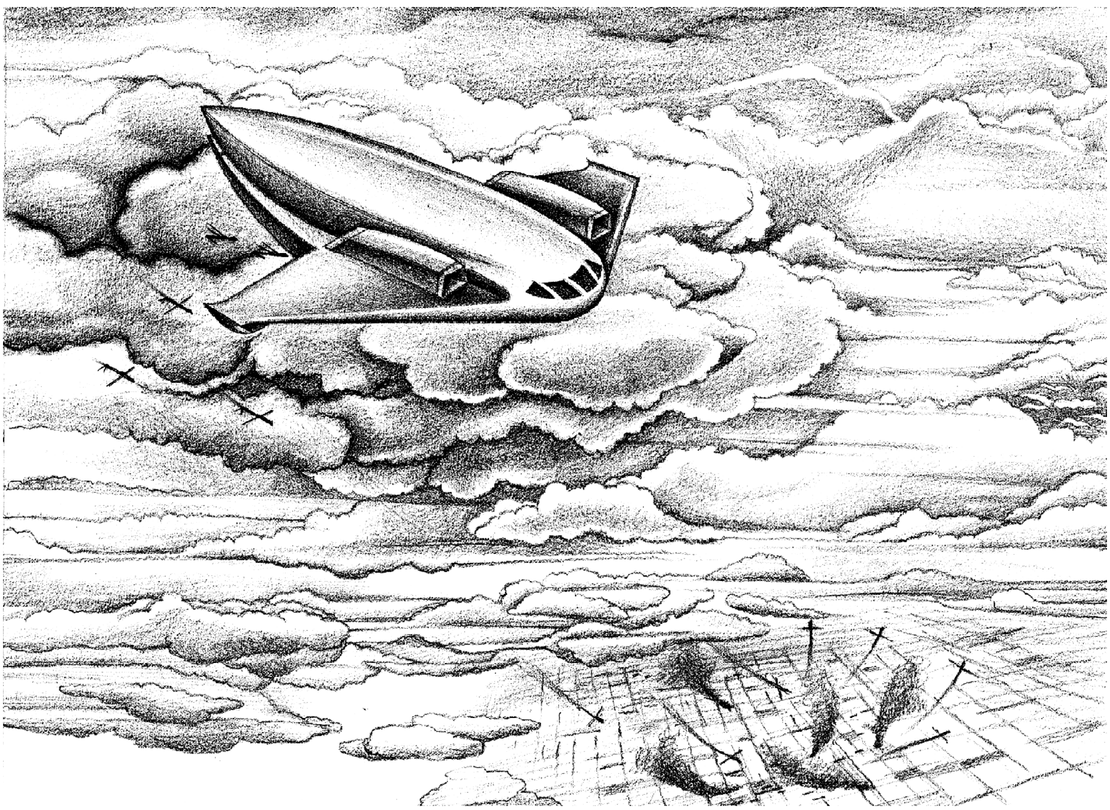
There will be a mix of inhabited and uninhabited aircraft. We use the term “uninhabited” rather than “unpiloted” or “unmanned” to distinguish the aircraft enabled by the new technologies from those now in operation or planned. The “unmanned” aircraft of the present have particular advantages such as cost or endurance, but they are either cruise missiles or reconnaissance vehicles. The “uninhabited” combat aircraft (UCAV) are new, high performance aircraft that are more effective for particular missions than are their inhabited counterparts. The UCAV is enabled by information technologies, but it enables the use of aircraft and weapon technologies that cannot be used in an aircraft that contains a human. There will be missions during the next three decades that will benefit from having a human present, but for many missions the uninhabited aircraft will provide capabilities far superior to those of its inhabited cousins. For example, shape and function will not be constrained by a cockpit, a human body, or an ejection seat. We believe that the design freedom generated will allow a reduction in radar cross section by at least 12 dB in the frequency bands currently addressed, compared to existing aircraft. A 12 dB reduction in aircraft cross section will reduce the effective range of enemy radar by a factor of two and area coverage by a factor of four. At this point we reach the limit of passive radar cross section reduction, and active methods must be developed. Also, reduction of infrared emissions is an important area where substantial improvements can be made. Other advantages

---

8. We will use the terms “discontinuous change” and “revolutionary” interchangeably

of the UCAV will be described later. There is the possibility of extending UCAV performance into the hypersonic range to enable strikes from the CONUS on high value targets in minutes.

Large and small aircraft will project weapons. At present we think of large aircraft as bombers, tankers, surveillance aircraft, or air launched cruise missile (ALCM) launch platforms. In the future large aircraft will be the first to carry directed energy weapons, and their entry into combat as formidable tactical weapons will cause a discontinuous change in aerospace warfare. Eventually, after establishing their value aboard aircraft, directed energy weapons will move into space. Small UCAVs can be carried aboard and launched from large aircraft to provide intercontinental standoff capability.



Attack by Low Observable UCAVs Deployed by Airlifter

Explosive weapons will be substantially more accurate than those of today, and explosive effectiveness per unit mass will be higher by at least a factor of ten than those of today. As a result, a sortie of the future can be ten times more effective than one of today. Weapon types will range from inexpensive enhanced accuracy weapons without sensors to GPS directed weapons with better than one foot accuracy to microsensor directed microexplosive systems that kill moving targets with grams of explosive.

We must extend airlift capabilities. The current generation of military airlifters and commercial transport aircraft will be useful for the next three decades, but replicating these aircraft with evolutionary upgrades will not provide the necessary capabilities. Even the addition of the Civil Reserve Air Fleet (CRAF) cannot provide enough airlift capacity for the future, and while commercial airlifters will form an important component of the future airlift fleet, their capabilities are limited, and they cannot be exchanged one for one with military airlifters. The future airlifter should be large (10^6 pounds gross takeoff weight), efficient (1.3-1.5 times current aircraft), and long range (12,000 nm). It should have point-of-use delivery capability through precision airdrop as a routine delivery process. Full airdrop capability will reduce theater infrastructure requirements for both the Air Force and the Army at forward locations. Rapid tempo of operations will require rapid resupply. As we take advantage of the operational possibilities enabled by technology, the Air Force of the future will be limited by logistics considerations just as surely as were the forces of Hannibal and Napoleon. We must pay close attention.

The future force will become efficient and effective through the use of information systems to enhance US operations and to confound the enemy. The infancy of this capability is represented today in the F–22. Information and Space will become inextricably entwined. The Information/Space milieu will interact strongly with the air and ground components, and it is here that commercial technologies and systems will have the largest presence. Defense will not be a driver of important technologies in this area. Surveillance and reconnaissance will be done worldwide from commercial platforms, and international conglomerates may own some of those platforms. High resolution mapping services from space will be purchased. Worldwide weather monitoring will be possible, although current systems are not capable of adequate precision. Precise timing and positioning services will be provided by a new ultra precise, jam resistant Global Positioning System (GPS). Communication of information and instructions throughout the Force will be instantaneous over fiber and satellite networks. Computers and displays will be common, commercial units. Even avionics processors and data busses will be purchased off the shelf. As we improve the capabilities of information equipment, we should remember that the human is an integral part of the system. We must improve the capabilities of the human-machine interface as we improve the machine.

There is an area where development of defense information systems may diverge from development of commercial systems. Those are *systems used in Information Warfare (IW)*. The use of "information munitions" in offensive operations will become an essential component of warfare. The use of "information munitions" will, however, make unusual demands on software and equipment. At present, it appears as though Information Warfare is more of a "bag of tricks" than a system of warfare. As the technologies are better defined, this will change. We must constantly make IW more robust and more effective. Information Warfare has three components. One is the method, or core, of IW which uses computers and software to deceive and destroy enemy information systems. The second component is deployment. Deployment may be as simple as connecting to the Internet, or it may require special communication systems, high power microwave systems, special forces action, or surreptitious individual action. The final component is Defense. Defensive IW will be pursued by the commercial community because of the obvious effects that malicious mischief can have on commerce. The military problem is, however, likely to be different enough that some effort will be required. The commercial solutions should be monitored closely. It is the union of method, deployment, and defense which creates the Information Munition. These components must not become separated if maximum effectiveness is to be achieved.

Space and space systems will become synonymous with effective operations. In addition to government investment in military systems, US companies will have large investments in space and information systems. The protection of our assets and the denial of capabilities to an enemy will be essential. The future Force will, eventually, contain space, ground, and airborne weapons that can project photon energy, kinetic energy, and information against space and ground assets. Many space and information weapons will destroy. Others will confuse the enemy and weave the "bodyguard of lies"[9] that will protect our forces.[10]

Sensors and information sources will be widely distributed. Sensors onboard fighter aircraft will continue to be important, but they will form a progressively smaller part of the total information source for combat operations. Fighter-mounted sensors, too, will supply information to companion craft as often as they provide information to their bearer. There will be sensors functioning cooperatively aboard small, distributed satellite constellations, sensors aboard uninhabited reconnaissance aerial vehicles (URAVs), sensors aboard weapons, and sensors on the ground delivered by URAVs. We often speak glibly about enhancing capability through information, but we as often forget that information originates as data from active and passive sensors.[11] The power of the new information systems will lie in their ability to correlate data automatically and rapidly from many sources to form a complete picture of the operational area, whether it be a battlefield or the site of a mobility operation. In particular, the accuracy of a single sensor and processor in identifying targets or threats is severely limited. Detection and identification probabilities increase rapidly with sensor diversity and the false alarm probability and error rates decrease correspondingly.

Affordability restrictions demand caution at this point. For the technologist, the intellectual lure of ultra precise sensors and control systems aboard munitions flying at hypersonic speeds is seductive. But, sensors and control systems constitute a large fraction of the cost of a munition, and we see no substantial change to this situation in the future. We properly laud the improvement in capability generated by precision guided weapons. We sometimes forget, however, that Precision Guided Munitions (PGMs) do not always produce an increased operational advantage proportional to their increased cost. This situation can change as a result of reduced sensor costs in the future or as the result of reduced performance requirements. It will always be cheaper to carry reusable precision sensors aboard a reusable delivery platform and either to eliminate guidance and control on board the munitions entirely or to use rather inaccurate onboard systems. The trade between munition precision and platform precision will, of course, depend on the survivability of the platform at appropriate release distances and the dependence of cost on munition accuracy. It may be possible to reduce the cost of precision delivery by building reusable, close approach delivery platforms that have precision positioning and

9. Winston Churchill, said to Josef Stalin; Teheran; November, 1943
10. General Ronald R. Fogleman, Speech to NDU/NSIA Global Information Explosion Conference, National Defense University, 16 May 1995
11. Sensors Volume

sensing systems, reproducible weapon release, and wind measuring equipment onboard. Munitions can be built with low drag coefficients. Significant cost reduction will result from the reuse of sensors and processors. The munition can either have no guidance or can have simple inertial or GPS guidance and low precision controls. This option favors the low observable UCAV for attack of mobile and protected targets.

Finally, the loop must be closed. The operational components of the Air Force must plan together, function together, command and be commanded, exchange information, and assess results collegially with each other, other services, and allies. Planning and directing must be done in parallel rather than in series to sustain high rate operations. Plans must be analyzed continuously at all levels by simulation. We refer to the construct that makes this possible as a complete "internetting of nodes" and as a seamless "operation across networks."[12] A node can be an airplane, a general, an Army private, a tank, or a UCAV. A collaborating network may be operated by the US Army or by an allied command. Internetting provides for the nearly direct connection of one of the nodes to any other node. Communication channel, processor, and terminal considerations determine the fundamental physical limitations, but with the exception of radio frequency (RF) channels, these limitations are vanishing as practical limitations to the internetting process. Even RF data channel capacities are increasing as the result of new compression algorithms and error correction schemes. Major difficulties remain, however, in establishing priorities for information transfer and in maintaining adequate security. Capture of nodes must not compromise system integrity. Elimination of these difficulties will be neither easy nor inexpensive. *We must solve the important security problems before the full impact of information sciences can be realized.*

This low resolution snapshot of the Force was intended to give the reader an idea of the extensive enhancement and integration of capabilities that will be possible in future decades. We hope that the applications of the new technologies are so profound that they are obvious and compelling, and we hope that they stimulate the reader to create personally pleasing combinations of capabilities. For example, improved stealth provides higher effectiveness against both aircraft and SAMs in establishing air superiority. Improved aircraft performance, say through UCAVs will increase survivability in high threat areas. Together, stealth and performance will reduce the reliance on electronic countermeasures with an accompanying reduction in cost and system volatility, and when directed by offboard information and passive sensors, they have the surprise value of a silent force. Large airlifters with point of use delivery capability can provide the military equivalent of "just in time" supply from CONUS, if necessary, with cost reductions and efficiency increases that are as large as those realized by commercial industries. Accompanied by airlifters carrying UCAVs and directed energy weapons for self defense, the airlifter fleet will become a survivable offensive weapon system in high threat areas. Distributed space systems can revisit areas of interest at rates not now possible. Distributed space sensors can operate cooperatively with staring sensors aboard Uninhabited Reconnaissance Air Vehicles (URAVs), which continuously monitor important targets, to optimize the collection and use of intelligence information.

A word about the application of commercial technologies is appropriate. No one doubts that many commercial technologies are applicable to military problems and that their use can

12. Information Applications Volume

reduce system costs and improve utility. There are, however, obligations concomitant with their use. Commercial technologies accompany commercial practices. We must be prepared to change requirements and operating procedures to agree with commercial practice if we are to make efficient use of commercial technology. *In the fields of space, communications, and information, the time from concept to deployment must be no longer than two years. Information systems should be replaced in five years.* Many processes can be improved by an injection of commercial practice, but the price paid for the improvement will be uncertainty in ultimate performance and survivability. Replacement of damaged units will become more acceptable than hardening to reduce cost. A program development culture that generates continuous improvement from humble beginnings rather than ultimate initial performance will be demanded. The new development culture will require an operational culture that can accept less than optimum performance today in exchange for rapid improvement tomorrow. We must demand reduced cycle time in procurement just as we will demand it in execution.

In the following chapters we will provide much more detail about technologies and concepts. Ultimately, however, the Panel Volumes and the Panel Members provide the depth necessary for implementation.

4.0 Revolutionary Concepts in Context

The word “revolutionary” is in common use, and overuse, today. *New World Vistas* proposes concepts that we believe to be revolutionary. The word has been used to mean many things, and it is useful to put the term into a context within which we can discuss new technologies and their use. The word is frequently used to identify a “silver bullet” -- a single concept or device that will immediately produce the ascendancy of the user’s forces over those of the user’s adversaries. The world is not like that. Science, technology, and military inventions are not like that. Nearly always, it is the evolutionary follow-on of a new concept that produces a revolution in capability. For example, the nuclear weapon was the most revolutionary weapon ever invented. It not only changed the nature of warfare but also it changed the nature of all interactions among nations, and it changed the way all science was viewed by the public. The first two nuclear weapons, however useful as a demonstration of the principle, would not, had they been duplicated many times, have had that affect. It was the evolutionary development of the thermonuclear weapon from the fission weapon coupled with the evolution of the ICBM from the V-2 that produced the profound effects on society. Frequently, too, it is the association of well-known principles in an innovative way that produces the revolutionary result. The geometric arrangement of junction voltages between semiconductors in an unusual way produced a transistor. The evolutionary development of Complimentary Metal-Oxide Semiconductor (CMOS) and integrated circuits has led to the information revolution.

Thus, we can seldom expect to produce truly revolutionary effects with the first manifestation of a new technology. In recognition of this fact, demonstrations should not include all aspects of a new technology. Smaller steps should be taken to minimize the total cost and to permit more flexibility. The first attempt to apply new concepts is a necessary, but not sufficient step. In military systems, the second step in the development of a radically new concept must be determined after operational deployment. The warfighters will use the system in innovative ways not described in the manuals, and it is this experience that will define the path to revolution.

We should keep some general guidelines in mind:

- The relationship between revolutionary and evolutionary concepts is complex and complementary.
- Revolutionary ideas often point the way to later applications which are far more useful than the original idea.
- Early applications of revolutionary concepts should not be required to be complete and final weapon systems.
- Identification and development of revolutionary concepts require intuition, innovation, and acceptance of substantial risk.
- We must be prepared for a failure rate greater than 50 percent.
- Most revolutionary ideas will be opposed by a majority of decision makers.
- We must remember that science and science fiction are related only superficially.

Examples of all these points abound. We invite readers to substitute their favorites.

5.0 The Report

The Air Force must become a force that is tightly integrated within itself, with the other Services, and with allies. It is difficult to write a report on *New World Vistas* that reflects the integration and, at the same time, displays the component parts in a way that makes their development clear. We will try to expose the nature of the problems and their solutions by writing the report from two aspects. In Chapter II, we will remove technologies from their applications and describe them separately, and we will describe concepts that collect the technologies into integrated units. The reader should constantly imagine each technology and each concept feeding and deriving support from the others.

In Chapter III, we will suggest the immediate tasks that will spawn the new technologies. We will even suggest a few fields now pursued which should be abandoned, although our knowledge of Air Force Science and Technology programs is not deep enough to make the list complete. In Chapter IV, we will suggest changing some of the management concepts for the Air Force Laboratories, and we will identify some characteristics of the Scientific Advisory Board (SAB) that can be used to make it more effective. It is well known, however, that self analysis is unlikely to be accurate.

Finally, we observe that the relationship of the Air Force to technology is a living, changing one. It is the character of the relationship and the dedication of the people in the Air Force to the application of the newest principles of science and technology that has made it the envy of the world. To the extent that *New World Vistas* is a part of this process, it should stimulate discussion and analysis as much as it defines new concepts, and its proposals are debatable. If our work causes the Air Force to examine and embrace the notion of discontinuous enhancement through technology, we have succeeded. If a few of our ideas find their way into the Force of the future, our efforts will have been well repaid.